Atty. Docket No. OPP031367US
Serial No: 10/728,706

Remarks

Applicant and his representatives wish to thank Examiner for the examination of the present application, and the explanations in the Office Action dated March 31, 2006. Applicants refer again to the Declaration of Kang-Hyun Lee as submitted with the Amendment filed on January 12, 2006, explaining the unexpected results provided by the presently claimed invention.

The present invention relates to a method for fabricating a metal line of a semiconductor device. The method generally forms a photoresist pattern on a metal layer, where the photoresist has a thickness of less than 9000 Å; forming a buffer layer on the photoresist pattern, including in an opening in the photoresist pattern; and removing the metal layer at a lower side of the opening by dry etching to form a plurality of metal lines. In one aspect, the photoresist pattern has an opening of less than or equal to 0.26 μm width (as recited in Claim 1 as previously presented), and in a related aspect, a ratio of the photoresist thickness to the width of the opening is less than about 3.5 (as recited in Claim 22 as previously presented). The method shows unexpected improvements in defect reduction relative to otherwise identical methods in which no buffer layer is formed on the photoresist pattern and either:

(i) The photoresist has a thickness greater than 9000 Å and a ratio of the photoresist thickness to the width of the opening is greater than about 3.5; or

(ii) The photoresist has a thickness less than 9000 Å (see, e.g., paragraph 4 of the Declaration of Kang-Hyun Lee).

This result is neither disclosed nor suggested by the cited references.

The Rejection of Claims 1, 3, 4, 18, and 20-22 under 35 U.S.C. § 103(a)

The rejection of Claims 1, 3, 4, 18, and 20-22 under 35 U.S.C. § 103(a) as being unpatentable over the Background as described in the present application in view of U.S. Patent No. 6,750,150 to Chung et al. (hereinafter, "Chung") is respectfully traversed.

The Examiner improperly relies on the Background section of the present application as prior art. According to MPEP § 2129, part II, where the specification identifies work done by another as "prior art," the subject matter so identified is treated as admitted prior art. *In re Nomiya*, 509 F.2d 566, 571, 184 USPQ 607, 611 (CCPA 1975) (holding applicant's labeling of two figures in the application drawings as "prior art" to be an admission that what was pictured was prior art relative to applicant's improvement). However, the specification of the present application does not identify any material whatsoever as "prior art." Furthermore, any teaching or suggestion to make the claimed combination must **not be based on the applicant's disclosure**. *In re Vaeck*, 947 F.2d 488 (Fed. Cir. 1991). Therefore it is improper to cite the disclosure of the present application as a reference against itself to make an obviousness rejection.

Prima Facie Obviousness

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Also, the reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination must be found in the prior art, and not based on applicant's disclosure. *Id.*

Even assuming, *arguendo*, that the Examiner can cite proper prior art that discloses the steps of forming an insulation layer on a semiconductor substrate on which devices or lower lines are formed, forming a metal layer on the insulation layer, forming a photoresist pattern having an opening on the metal layer, and removing the metal layer at a lower side of the opening by dry etching to form a plurality of metal lines, Chung fails to teach or suggest forming a buffer layer on a photoresist pattern having an opening on a metal layer. Chung further fails to teach or suggest such a method wherein the photoresist has a thickness of less than 9000Å.

The Examiner has stated that it would have been obvious to combine the prior art to use a buffer layer on the photoresist pattern as suggested by Chung in the process of forming a metal line. However, the Examiner has failed to show any art other than the applicant's own disclosure to provide such a suggestion or motivation to form a buffer layer on a photoresist pattern having an opening on a metal layer. The Examiner's burden is not just to state or show that such a motivation could exist, but to show that such a motivation would exist for a person of ordinary skill in the art at the time of the invention.

As shown in MPEP § 2143.01, "the test for an implicit showing is what the combined teachings, knowledge of one of ordinary skill in the art, and the nature of the problem to be solved as a whole **would** have suggested to those of ordinary skill in the art." *In re Kotzab*, 217 F.3d 1365, 1370, 55 USPQ2d 1313, 1317 (Fed. Cir. 2000). See also *In re Lee*, 277 F.3d 1338, 1342-44, 61 USPQ2d 1430, 1433-34 (Fed. Cir. 2002) (discussing the importance of relying on objective evidence and making specific factual findings with respect to the motivation to combine references) (emphasis added).

Chung relates to a semiconductor manufacturing method that includes defining a substrate, depositing a polysilicon layer over the substrate, depositing a layer of photoresist over the polysilicon layer, patterning and defining the photoresist layer, depositing a layer of inorganic material over the patterned and defined photoresist layer where the layer of inorganic material is conformal and photo-insensitive, and anisotropically etching the layer of inorganic material and the layer of semiconductor material (Abstract).

The Examiner in the present application has failed to show that a person of ordinary skill in the art at the time of the invention would have been motivated to apply Chung's teachings regarding polysilicon etching to a method for forming *metal* lines (again, assuming *arguendo* that the Examiner can provide proper prior art with respect to forming metal lines). Thus, the Examiner has failed to make a *prima facie* case of obviousness. Therefore, the rejection of Claims 1, 3, 4, 18, and 20-22 under 35 U.S.C. § 103(a) as being unpatentable over the Background as described in the present application in view of Chung is improper, and should be withdrawn.

Unexpected Results

For the sake of argument, even if a *prima facie* case of obviousness could be made, the present invention is nonobvious over the prior art because the invention produces unexpected results. As shown in MPEP § 716.02(a), "a greater than expected result is an evidentiary factor pertinent to the legal conclusion of obviousness ... of the claims at issue." *In re Corkill*, 711 F.2d 1496, 226 USPQ 1005 (Fed. Cir. 1985). MPEP § 716.02(b) tells that nonobviousness can be established if "the differences in results are in fact unexpected and unobvious and of both statistical and practical significance." *Ex parte Gelles*, 22 USPQ2d 1318, 1319 (Bd. Pat. App. & Inter. 1992). As shown in the Declaration of Kang-Hyun Lee (submitted with the Amendment filed on January 12, 2006), the present invention produces greater than expected results over the prior art that are of statistical and practical significance, because the invention produces observed improvements in defect reduction, and transforms a process with commercially unacceptable levels of defects into a process with commercially acceptable levels of defects (see paragraph 15 of the Lee Declaration).

Chung relates to a method including the steps of depositing a layer of photoresist over a polysilicon layer, patterning and defining the photoresist layer, and depositing a layer of inorganic material over the photoresist layer (Abstract). Chung does not disclose forming a photoresist and buffer over a metal layer. Step (e) in the present Claims 1 and 22 recites "selectively removing the metal layer at a lower side of the opening by dry etching to form a plurality of metal lines." In processes used to manufacture commercial semiconductor devices, to form a plurality of metal lines successfully, gaps between adjacent metal lines are formed without defects that cause a short circuit between the adjacent metal lines (see, e.g., paragraph 5 of the Lee Declaration).

In processes used to manufacture commercial semiconductor devices in which a critical dimension between adjacent metal lines is 0.26 μm or less, a problem arises when the photoresist has a thickness greater than 9000 Å. In this case, the openings in the photoresist have an aspect ratio (i.e., the ratio of the photoresist thickness to the width of the opening) of greater than about 3.5. In other words, since 9000 Å/2600 Å (0.26 μm) is about 3.5 (using 2 significant digits), a

photoresist thickness of > 9000 Å divided by a width of 0.26 μm leads to an aspect ratio of > about 3.5 (see paragraphs 6-7 of the Lee Declaration).

The relationship between the aspect ratio of the openings in the photoresist and the width of the openings in the photoresist is direct and quite clear, as the statement in paragraph 7 of the Lee Declaration establishes. In other words, the width of the opening times the aspect ratio equals the height of the photoresist. Therefore, the unexpected results described in the Lee Declaration for a method that forms a buffer layer on a photoresist pattern on a metal layer, where the photoresist has a thickness of less than 9000 Å, and a ratio of the photoresist thickness to the width of an opening in the photoresist is less than about 3.5 (Claim 22 as previously presented), are applicable to a photoresist pattern having a thickness of less than 9000 Å and an opening of less than or equal to 0.26 μm width (Claim 1 as previously presented).

When the openings in the photoresist have an aspect ratio > about 3.5, the aspect ratio of the gap formed between adjacent metal lines having relatively thick photoresist thereon increases. This increase results in an increased likelihood of the formation of metal "stringers" or other defects at the bottom of the gaps between the resulting metal lines that result in a short circuit between adjacent metal lines. In the case where the photoresist has a thickness greater than 9000 Å and the openings in the photoresist have an aspect ratio > about 3.5, the increased likelihood of metal "stringers" or other short circuit-causing defects is unacceptably high for a commercial manufacturing process (see paragraphs 8-9 of the Lee Declaration).

One possible solution to this metal "stringer" problem is to reduce the photoresist thickness to less than 9000 Å. (In a commercial semiconductor manufacturing process, one generally cannot reduce the metal layer thickness without adversely affecting performance of the manufactured semiconductor devices.) However, in many commercial semiconductor manufacturing processes, a thickness of less than 9000 Å for a conventional photoresist may not be sufficient to dry etch the metal layer under the photoresist (see the last step in claims 1 and 22 as previously presented; also see paragraph 10 of the Lee Declaration).

Typical conditions for dry etching a metal layer in commercial semiconductor manufacturing processes are generally not sufficiently selective with respect to the photoresist to ensure that an adequate amount of photoresist remains over the metal layer to prevent inadvertent etch damage to the top of the metal layer. Thus, when the photoresist thickness is less than 9000 Å in commercial CMOS semiconductor manufacturing processes, there is an increased likelihood of damage to the upper surfaces of the resulting metal lines that can degrade performance of the resulting semiconductor devices and/or adversely affect subsequent processing (e.g., anti-reflective coatings formed at or on the upper surface of the metal lines may have unacceptable anti-reflective properties). In this case, the increased likelihood of dry etch damage to the upper surface of the metal lines is unacceptably high for a commercial semiconductor manufacturing process (see paragraphs 11-12 of the Lee Declaration).

To solve these "metal stringer" and dry etch damage problems, the present method (e.g., as recited in Claim 22 as previously presented) first forms a photoresist pattern on the metal layer, where the photoresist has a thickness of less than 9000 Å and a ratio of the photoresist thickness to the width of an opening in the photoresist is less than about 3.5, then forms a buffer layer on the photoresist pattern, including in the opening (see paragraph 13 of the Lee Declaration). Alternatively, the present method may form a photoresist pattern having an opening of less than or equal to 0.26 μm width and a thickness of less than 9000 Å on the metal layer, then forms a buffer layer on the photoresist pattern, including in the opening (see amended Claim 1 as previously presented).

The present method (as exemplified by Claim 22 as previously presented) above reduces the likelihood of "metal stringer" (or other short circuit-causing) defects and any adverse effects from dry etch damage to an upper surface of metal lines to levels or values that are acceptable for commercial semiconductor manufacturing processes (see paragraph 14 of the Lee Declaration). Given the direct relationship between aspect ratio and width of an opening in a photoresist pattern as established by paragraph 7 of the Lee Declaration, the improvements provided by the present method (as exemplified by Claim 22 as previously presented) are also applicable to a

photoresist pattern having a thickness of less than 9000 Å and an opening of less than or equal to 0.26 μm width (see amended Claim 1 as previously presented).

While Chung seeks to enhance the etching resistance of a patterned photoresist layer (col. 1, ll. 37-39), Chung appears to be silent with regard to any defect reduction effects of reducing the likelihood of "metal stringer" (or other short circuit-causing) defects. Accordingly, Chung cannot suggest the observed improvements in defect reduction provided by the present method as a result of forming a buffer layer on a photoresist pattern. Thus, the present invention provides unexpected results that are commercially significant, as evidenced by the Declaration of Lee. Therefore, any *prima facie* showing of the obviousness of independent Claims 1 and 22 in view of Chung is overcome by the evidence of unexpected results. Accordingly, the rejection of independent Claims 1 and 22, and dependent Claims 3, 4, 18, 20, and 21 under 35 U.S.C. § 103(a) as being unpatentable over the Background as described in the present application in view of Chung is improper, and should be withdrawn.

The Rejection of Claims 2 and 5-17 under 35 U.S.C. § 103(a)

The rejection of Claims 2 and 5-17 under 35 U.S.C. § 103(a) as being unpatentable over the Background as described in the present application in view of Chung and U.S. Patent No. 6,383,942 to Narita et al. (hereinafter, "Narita") is respectfully traversed.

One of ordinary skill in the art of semiconductor manufacturing would not understand or appreciate from reading the Narita and Chung patents that the present method (e.g., as recited in Claim 22 as previously presented) would provide the observed improvements in defect reduction (i.e., from commercially unacceptable levels to commercially acceptable levels; see paragraph 15 of the Lee Declaration). Given the direct relationship between aspect ratio and width of an opening in a photoresist pattern as established by paragraph 7 of the Lee Declaration, the unexpected improvements provided by the present method (exemplified by Claim 22 as previously presented) are also applicable to a photoresist pattern having a thickness of less than

9000 Å and an opening of less than or equal to 0.26 μm width (see amended Claim 1 as previously presented).

Narita disclose a dry etching method for use in patterning stacked metal films containing aluminum as the base component and a thin film including at least one of titanium and titanium nitride. In this method, the thin film is dry-etched using a first etching gas composition for preventing the metal film from being processed. The metal film is then dry-etched using a second etching gas composition other than the first etching gas (Abstract).

The method of Narita intends to provide a dry etching method capable of patterning a stacked film such that the thin film is formed vertically and the metal film is prevented from being side-etched (col. 2, ll. 47-53) and/or reduce a pattern transfer difference in a stacked film (col. 3, ll. 1-4). As the Examiner correctly recognizes, Narita do not disclose forming a buffer layer as claimed.

For example, Narita discloses a dry etching method for use in patterning stacked metal films containing aluminum as the base component and a thin film including at least one of titanium and titanium nitride (Abstract). The method of Narita intends to provide a dry etching method capable of patterning a stacked film such that the thin film is formed vertically, and the metal film is prevented from being side-etched (col. 2, ll. 47-53) and/or a pattern transfer difference is reduced in the stacked film (col. 3, ll. 1-4 of Narita; see also paragraph 16 of the Lee Declaration).

Narita teaches that the width of processed wiring usually becomes larger than that of a mask when a mask pattern is formed on the stacked film, and then the stacked film is processed by dry etching (col. 10, ll. 18-21). In such a case, it is likely that an interval (or gap) between wiring portions will be narrowed, and a short circuit will be caused easily between them (Narita, col. 10, ll. 21-24). This disclosure is consistent with the discussion in paragraphs 8-9 above regarding the "metal stringer" problem (see paragraph 17 of the Lee Declaration).

Narita further teaches that this problem is difficult to solve in miniaturized devices using conventional approaches (col. 10, ll. 35-36). For example, the wiring cannot be thinned because

its resistance is increased, and accordingly, the photoresist mask pattern cannot be reduced in thickness (Narita, col. 10, ll. 36-41). Consequently, Narita teaches that the mask is narrowed and the photoresist mask aspect ratio is increased, resulting in a phenomenon in which the mask pattern is easy to physically fall when it is washed after development (col. 10, ll. 41-45). This disclosure is consistent with the discussion in paragraph 10 above regarding problems resulting from conventional solutions to the "metal stringer" problem (see paragraph 18 of the Lee Declaration).

Narita appears to be silent with regard to forming a buffer layer on a photoresist pattern. Accordingly, Narita cannot suggest the observed improvements in defect reduction provided by the present method (as recited in paragraph 3 of the accompanying Lee Declaration and Claim 22 as previously presented) as a result of forming a buffer layer on a photoresist pattern (see paragraph 19 of the Lee Declaration). Given the direct relationship between aspect ratio and width of an opening in a photoresist pattern as established by paragraph 7 of the Lee Declaration, the deficiencies of Narita are also applicable to an identical method in which the photoresist has a thickness of less than 9000 Å and the photoresist pattern has an opening of less than or equal to 0.26 μm width (see amended Claim 1 as previously presented).

Chung discloses a semiconductor manufacturing method that includes defining a substrate, depositing a polysilicon layer over the substrate, depositing a layer of photoresist over the polysilicon layer, patterning and defining the photoresist layer, depositing a layer of inorganic material over the patterned and defined photoresist layer where the layer of inorganic material is conformal and photo-insensitive, and anisotropically etching the layer of inorganic material and the layer of semiconductor material (Abstract; see also paragraph 20 of the Lee Declaration).

While it is an object of the invention of Chung to enhance the etching resistance of a patterned photoresist layer (col. 1, ll. 37-39), Chung appears to be silent with regard to any defect reduction effects of forming the layer of inorganic material over the patterned and defined photoresist layer. Accordingly, Chung cannot suggest the observed improvements in defect reduction provided by the present method (recited in paragraph 3 of the Lee Declaration and

Claim 22 as previously presented) as a result of forming a buffer layer on a photoresist pattern. Given the direct relationship between aspect ratio and width of an opening in a photoresist pattern as established by paragraph 7 of the Lee Declaration, the deficiencies of Chung are also applicable to an identical method in which the photoresist has a thickness of less than 9000 Å and the photoresist pattern has an opening of less than or equal to 0.26 μm width (see amended Claim 1 as previously presented).

As a result, the observed improvements in defect reduction provided by the present method (e.g., as recited in paragraph 3 of the Lee Declaration and Claim 22 as previously presented) are unexpected in view of the Narita and Chung patents. Given the direct relationship between aspect ratio and width of an opening in a photoresist pattern established by paragraph 7 of the Lee Declaration, the unexpected improvements provided by the present method (exemplified by Claim 22 as previously presented) are also applicable to an identical method in which the photoresist has a thickness of less than 9000 Å and the photoresist pattern has an opening of less than or equal to 0.26 μm width (see amended Claim 1 as previously presented).

Consequently, both the present claims 1 and 22 provide improvements in defect reduction that are unexpected in view of the disclosures and teachings of Narita and Chung. As a result, the present claims 1 and 22 are fully patentable over Narita and Chung.

Claims 2 and 5-17 all depend directly or indirectly from Claim 1, and are therefore believed to be patentable for the same reasons as Claim 1. Thus, rejection of Claims 2 and 5-17 under 35 U.S.C. § 103(a) as being unpatentable over the Background as described in the present application in view of Chung and Narita is unsustainable, and should be withdrawn.

Conclusion

In view of the above amendments and remarks, all bases for objection and rejection are overcome, and the application is in condition for allowance. Early notice to that effect is earnestly requested.

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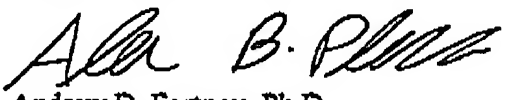
If it is deemed helpful or beneficial to the efficient prosecution of the present application, the Examiner is invited to contact Applicant's undersigned representative by telephone.

Respectfully submitted,



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